CLAIMS

1. A method of chemically treating a surface of a workpiece, comprising:

    exposing the surface of the workpiece to a direct flow of a precursor gas to form a surface reactant thereon;

    providing a flow of an input gas above the surface of the workpiece;

    preventing the mixture of said precursor gas and said input gas with a purge gas;

    directing a beam of electromagnetic radiation into said input gas to produce a high flux of generated reactive gas species; and

    reacting said generated reactive gas species with said surface reactant.

2. The method of claim 1, wherein said generated reactive gas species is selected from the group consisting of the noble gases, nitrogen, hydrogen, oxygen, and combinations thereof.

3. The method of claim 1 wherein the generated reactive gas species is selected from the group consisting of NO, OH, NH, N, F, CF_3, CF_2, CF, NF_2, NF, Cl, O, BCl_2, BCl, FCO, and combinations thereof.

4. The method of claim 1 wherein the input gas is selected from the group consisting of N_20, NO_2, NH_3, H_2, H_2O, N_2, O_2, O_3, CCl_4, BCl_3, CDF_3, CF_4, SiH_4, $CFCl_3$, F_2CO, $(FCO)_2$, SF_5NF_2, N_2F_4, CF_3Br, CF_3NO, $(CF_3)_2CO$, CF_2HCl, CF_2HBr, CF_2Cl_2, CF_2Br_2, CF_2CFCl, CF_2CFH, $CF_2CF_2CH_2$, NH_3, CHF_3, fluorohalides, halocarbons, and combinations thereof.

5. The method of claim 1 wherein the workpiece comprises a semiconductor substrate.

6. The method of claim 1 wherein said reaction between said reactive gas species and surface reactant produces a desired material monolayer on the surface of the workpiece.

7. The method of claim 1 wherein said electromagnetic radiation is ultraviolet radiation.

8. The method of claim 1 wherein separating said precursor gas and said input gas is accomplished by simultaneously pumping and evacuating said purge gas.

9. The method of claim 1 wherein said reactive gas species is generated a distance less than a few mean-free-path lengths of said reactive gas species above the surface of said workpiece.

10. A method of chemically treating a surface of a workpiece, comprising:

providing the workpiece to a chamber having a gaseous atmosphere containing a transmission gas that is substantially nonattenuating to preselected wavelengths of electromagnetic radiation;

exposing the surface of the workpiece to a direct flow of a precursor gas to form a surface reactant for atomic layer deposition;

providing a flow of an input gas over the surface of the workpiece;

preventing mixture of said precursor gas and said input gas with a purge gas;

directing a beam of electromagnetic radiation into said gaseous atmosphere, said beam converging in the flow of said input gas in close proximity to the surface of the workpiece, but spaced a finite distance therefrom, to dissociate said input gas into a high flux of generated reactive gas species; and

reacting said generated reactive gas species with said surface reactant.

11. The method of claim 10 wherein separating said precursor gas and said input gas is accomplished by simultaneously pumping and evacuating said purge gas.

12. The method of claim 10, wherein said precursor gas is flown from a first gas port of a dispenser unit.

13. The method of claim 12, wherein said input gas is flown from a second gas port of said dispenser unit.

14. The method of claim 13, wherein said purge gas is flown from a third gas port of said dispenser unit.

15. The method claim 14, wherein separating said precursor gas and said input gas is accomplished by simultaneously pumping said purge gas via said third gas port and evacuating said purge gas by a pair of evacuation ports provided on said dispenser unit.

16. The method of claim 15 further comprising causing relative motion between the surface, said dispenser unit and said beam to cause said dispenser unit and said beam to sweep over the surface of the workpiece.

17. The method of claim 10 further comprising directing said beam of electromagnetic radiation from a laser source through a transparent window of said chamber into said gaseous atmosphere.

18. The method of claim 17 wherein said transparent window is a window selected from the group consisting of quartz, sapphire, and zinc selenide.

19. The method of claim 10 further comprising causing relative motion between the surface and said beam to cause said beam to sweep over the surface of said workpiece.

20. The method of claim 10 wherein said beam is in the range of wavelengths of 248 nm and 193 nm, and having energy in the range of about 100 to about 5000 mJ/cm^2.

21. The method of claim 10, wherein said generated reactive gas species is selected from the group consisting of the noble gases, nitrogen, hydrogen, oxygen, and combinations thereof.

22. The method of claim 10 wherein said generated reactive gas species is selected from the group consisting of chlorine, fluorine, and molecules containing fluorine or chlorine.

23. The method of claim 10 wherein the input gas is selected from the group consisting of N_20, NO_2, NH_3, H_2, H_2O, N_2, O_2, O_3, CCl_4, BCl_3, CDF_3, CF_4, SiH_4, $CFCl_3$, F_2CO, $(FCO)_2$, SF_5NF_2, N_2F_4, CF_3Br, CF_3NO, $(CF_3)_2CO$, CF_2HCl, CF_2HBr, CF_2Cl_2, CF_2Br_2, CF_2CFCl, CF_2CFH, $CF_2CF_2CH_2$, NH_3, CHF_3, fluorohalides, halocarbons, and combinations thereof.

24. The method of claim 10 wherein the workpiece comprises a semiconductor substrate.

25. The method of claim 10 further comprising controlling the energy characteristics of said beam to match absorption characteristics of said input gas to produce said high flux of said generated reactive gas species.

26. The method of claim 10 where said transmission gas is a gas or mixture of gases that is non-attenuating to predetermined wavelengths of said electromagnetic radiation.

27. The method of claim 10 wherein said transmission gas is selected from the group consisting of argon, nitrogen, helium, neon, and combinations thereof.

28. The method of claim 10 further comprising delivering a diagnostic beam of radiation to monitor said surface during said processing.

29. The method of claim 10 wherein said purge is selected from the group consisting of nitrogen, is selected from the group consisting of argon, nitrogen, helium, neon, and combinations thereof.

30. The method of claim 10 wherein said flow of said input gas is provided over the surface of the workpiece in as a gas layer having a thickness that is at least large enough to accommodate said finite distance.

31. The method of claim 10 wherein said finite distance less than a few mean-free-path lengths of said reactive gas species above the surface of the workpiece.

32. The method of claim 25 wherein said generated reactive gas species is selected from the group consisting of NO, OH, NH, N, F, CF_3, CF_2, CF, NF_2, NF, Cl, O, BCl_2, BCl, FCO, and combinations thereof.

33. A method for processing a surface of a workpiece comprising:

selecting a set of reaction parameters;

loading said substrate into a reaction chamber;

pumping on said reaction chamber until a pressure according to said selected reaction parameters is achieved;

translating said substrate at a constant rate across said chamber according to selected reaction parameters;

flowing into said chamber a precursor gas, a purge gas, and an input gas according to said selected reaction parameters;

evacuating said purge gas and any gases/residuals in vicinity of said purge gas to prevent mixing of the precursor and input gases; and

delivering a beam of electromagnetic radiation according to said selected reaction parameters into the flow if said input gas to produce a high flux of point of use generated reactive gas species which reacts with a surface reactant formed from said precursor gas impinging on said surface of workpiece at selected locations.

34. The method of claim 33 further comprising flowing into said chamber a transmission gas.

35. The method of claim 33 wherein said pressure is from about 0.1 Torr to about 100 Torr.

36. The method of claim 33 wherein said surface reactant and said reactive gas species react to form a monolayer of a material.

37. The method of claim 33 further comprising checking formation of said monolayer of said material on the surface of the workpiece for completeness according to said selected reaction parameters.

38. The method of claim 33 further comprising purging completely said chamber and removing said workpiece from said chamber after completion of said processing according to said selected reaction parameters.

39. The method of claim 33 further comprising directing said beam through a window of said chamber.

40. The method of claim 33 further comprising causing relative motion between said workpiece and said beam.

41. The method of claim 33 wherein said flows of said input gas, precursor gas and purge gas are provided from a dispenser unit, wherein said dispenser unit further includes a pair of evacuation ports to evacuate at least said purge gas.

42. The method of claim 41 further comprising causing relative motion between said workpiece, said beam, and said dispenser unit.

43. A system for chemically treating a surface of a workpiece comprising:

a supply of an input gas;

a supply of a precursor gas;

a supply of a purge gas;

a dispenser unit adapted to expose the surface of the workpiece to a direct flow of said precursor gas for a surface reactant formation, to provide a flow of said input over the workpiece, and to provide said purge gas between said precursor gas and said input gas to prevent mixing of said precursor and input gases, said dispenser unit further having a pair of evacuation ports for evacuating said purge gas; and

a source adapted to converge a beam of electromagnetic radiation in said flow of said input gas in close proximity to the surface of the workpiece, but spaced a finite distance therefrom, to dissociate said input gas into a high flux of generated reactive gas species that reacts with said surface reactant to chemically treat said surface of said workpiece.

44. The system of claim 43, further comprising a flow of a transmission gas provided over said flow of said input gas, said transmission gas being substantially nonattenuating to preselected wavelengths of said electromagnetic radiation.

45. The system of claim 43 further comprising a structure for causing relative motion between the surface of the workpiece, said dispenser unit, and said beam.

46. The system of claim 43 further comprising a chamber for containing said workpiece and said gases during said processing, said chamber having a window transparent to said electromagnetic radiation.

47. The system of claim 43 wherein said electromagnetic radiation is ultraviolet radiation.

48. The system of claim 43 further comprising optics to focus said beam.

49. The system of claim 48, wherein said optics further expand a cross sectional dimension of said beam such that said beam convergence into a wide scanning beam.

50. The system of claim 43 wherein said finite distance is less than a few mean-free-path lengths of said generated reactive gas species.

51. The system of claim 43 wherein said chamber further comprising a pair of exhaust pump for pumping on said evacuation ports and for exhausting gases from said chamber.

52. The system of claim 43 wherein said dispenser unit includes a nozzle connected to said supply of input gas to provide a laminar flow across the surface of the workpiece.

53. The system of claim 43 wherein said chamber further comprises heating and cooling components.

54. The system of claim 46 wherein said chamber further includes a workpiece temperature sensor for measuring the temperature of the workpiece during processing; a pressure sensor for measuring the gas pressures in the chamber during processing, and a gas sensor for monitoring at least said generated reactive gas species.

55. The system of claim 43 further comprising at least one mixing chamber.

56. The system of claim 43 further comprising a controller adapted to control said chemical treatment according to a selected set of reaction parameters.

57. The system of claim 43 further comprising a monitor adapted to monitor completion of said chemical treatment.

58. The system of claim 43 further comprising a beam dump adapted to absorb reflected energy of said beam.

59. The system of claim 43 wherein said dispenser unit is one of a plurality of dispenser unit and said beam is one of a plurality of beams.

60. A dispenser unit adapted for use in a reaction chamber for atomic layer deposition of a material onto a surface of a workpiece, comprising:

a first gas port adapted to provide a flow on an input gas over the surface of the workpiece to be dissociated by a radiation beam into a point of use generated reactive species;

a second gas port adapted to provide a direct flow of a precursor gas onto the surface of the workpiece which by chemisorption forms a first surface reactant;

a third gas port adapted to flow a purge gas to prevent mixing of said input and precursor gases; and,

a pair of evacuation ports adapted to evacuation at least said purge gas.

61. The dispenser unit of claim 60, further comprising a fourth gas port adapted to provide a transmission gas to the reaction chamber.